MA 33: Altermagnets IV

Time: Wednesday 15:00–18:30 Location: HSZ/0002

MA 33.1 Wed 15:00 HSZ/0002

Magnon transport and surface effects in an altermagnetic toy model — •Moumita Kundu[1], Rabea Schmidhuber[2], Marian Duelli[1], and Ulrich Nowak[1] — [1]Fachbereich Physik, Universität Konstanz, Konstanz, Germany — [2]Ludwig-Maximilians-Universität München, Geschwister-Scholl-Platz 1, 80539 München, Germany

Altermagnets are a recently discovered class of magnetic materials that show non-relativistic spin-splitting of the magnon bands and on exposure to a thermal gradient can carry a net magnetization unlike conventional antiferromagnets. Here, we present a simplistic toy model of an altermagnet having asymmetric exchange interactions in a checkered antiferromagnetic lattice. Using atomistic spin dynamic simulations based on the stochastic-LLG equation we obtain the spin dynamics. The altermagnetic phase is confirmed from magnon dispersions under a steady thermal excitation revealing chiral spin splitting as expected along one of the high-symmetry directions [110] and directions orthogonal to it. Surface effects are a direct outcome from these calculations, showing an orientation dependent surface magnetization detected for each cut of the sample. The spin Seebeck and spin Nernst effects are investigated both showing unique orientation dependent net magnetization and magnon accumulations following the lattice symmetries. Owing to the nondegenerate magnons branches, the group velocities of the corresponding magnons vary leading to distinct propagation lengths of the RH- and LH- modes predominant along different directions. The robustness to external magnetic fields is explored revealing preferential band liftings with an additional gap at the Γ point.

MA 33.2 Wed 15:15 HSZ/0002

Skyrmion dynamics in altermagnets — •Nicolai Timon Bechler and Jan Masell — Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

Altermagnetism is a new type of magnetic order that combines the time-reversal symmetry breaking nature of ferromagnetism with the stray-field free nature of antiferromagnetism. [1] Altermagnets can host skyrmions - whirling magnetic textures that are characterized by an integer real-space topological winding number. In d-wave altermagnets, the skyrmions in both sublattices are elliptical, related by lattice symmetries, and the total winding number vanishes as the contributions of each sublattice cancel each other. In this talk, we explore the motion of skyrmions in d-wave altermagnets, driven by either spin transfer torque (STT) or a magnon current. We combine an analytical collective-coordinate approach with high-precision micromagnetic simulations. Our findings predict that the anisotropic skyrmion profile yields a genuine Hall response beyond conventional Zhang-Li STT. In turn, standard Zhang-Li STT yields no Hall-signal but large artifacts in simulations which were previously misinterpreted as a physical Hall effect. [2] Furthermore, we show that for a system driven by a magnon current, the anisotropic scattering cross-sections immediately lead to a skyrmion Hall effect.

[1] L. Šmejkal et al., Emerging Research Landscape of Altermagnetism. Phys. Rev. X 12, 040501 (2022). [2] Z. Jin et al., Skyrmion hall effect in altermagnets. Phys. Rev. Lett. 133, 196701 (2024).

MA 33.3 Wed 15:30 HSZ/0002

Unconventional Magnetism in Fe-Based Materials — Reuel Dsouza[1], Andreas Kreisel[1], Brian M. Andersen[1], Daniel Agterberg[2], and •Morten H. Christensen[1] — [1]Niels Bohr Institute, University of Copenhagen, 2200 Copenhagen, Denmark — [2]Department of Physics, University of Wisconsin-Milwaukee, Milwaukee, Wisconsin 53201, USA

Odd-parity magnetism constitutes an intriguing phase of matter which breaks inversion symmetry while preserving time-reversal symmetry. Here we demonstrate that the Fe-based superconductors exhibiting coplanar magnetic order realize an odd-parity magnetic state by combining low-energy modeling with density-functional theory. In the absence of spin-orbit coupling, the electronic spins are polarized along the k_z-direction and the splitting of the up and down states exhibits an h- wave form-factor. The magnitude of the splitting depends sensitively on specific parameters of the low-energy model, including specific out-of-plane hopping parameters and the Fermi energies of the hole- and electron-pockets. Interestingly, despite this state breaking inversion symmetry and exhibiting a finite out-of-plane Berry curvature and non-linear anomalous Hall effect, the Edelstein effect vanishes. Incorporating spin-orbit coupling tilts the momentum-space electronic spins into the (k_x, k_y)-plane and imparts finite in-plane components to the Edelstein response. Our findings highlight the Fe-based superconductors as platforms for exploring odd-parity magnetism both on its own and coexisting with unconventional superconductivity.

MA 33.4 Wed 15:45 HSZ/0002

Optical investigations of electron-doped $FeSb_2$ — Renjith Mathew Roy[1], •Maxim Wenzel[1], Maksim Povolotskiy[1], Christian Prange[1], Artem Pronin[1], Yujie Xie[2], Tiantian Zhang[2], Vignesh Sundaramurthy[3], Maximilian van de Loo[4], Jule Kirschke[4], Andreas Kreyssig[4], Anna Böhmer[4], and Martin Dressel[1] — [1]1. Physikalisches Institut, Universität Stuttgart — [2]Institute of Theoretical Physics, Chinese Academy of Science, 100190 Beijing, China — [3]Max-Planck-Institute for Solid State Research, 70569 Stuttgart — [4]Experimental Physics IV, Ruhr Universität Bochum

While the marcasite-structured semiconductor $FeSb_2$ is nonmagnetic, theoretical predictions suggest that hole or electron doping can stabilize an altermagnetic order with a substantial non-relativistic spin splitting of approximately 0.2 eV [1].

Here, we investigate a series of Co-doped $FeSb_2$ samples using optical spectroscopic techniques including broadband infrared spectroscopy, Müller-matrix ellipsometry, and Raman scattering. Combined with density-functional theory calculations, we discuss the effects of electron doping and the consequent magnetic ordering on the electronic structure and optical phonon modes. In particular, we address the possibility of an emerging altermagnetic state for dopings above $x = 0.12$.

[1] I. I. Mazin, K. Koepernik, M. D. Johannes, R. González-Hernández, L. Šmejkal, PNAS **118**, e2108924118 (2021)

MA 33.5 Wed 16:00 HSZ/0002

Realization of epitaxial thin films of CrSb altermagnetic candidate material — •Edouard Lesne and Claudia Felser — Max-Planck-Institute für Chemische Physik fester Stoffe

CrSb belongs to a newly identified class of antiferromagnetically ordered materials coined altermagnets, whose spin-sublattices arrangement breaks time-reversal symmetry, giving rise to alternating spin-split bands with lifted Kramers degeneracy throughout the Brillouin zone. CrSb crystallizes in the hexagonal NiAs-type structure ($P6_3/mmc$) and exhibits a high antiferromagnetic ordering temperature (700-710 K), making it an ideal altermagnetic candidate material for room-temperature studies and prospective technological use in antiferromagnetic spintronic architectures.

We resort to a combination of X-ray diffraction, SQUID magnetometry and electrical magnetotransport techniques to investigate the intertwined structural, magnetic, and electronic transport properties of CrSb epitaxial thin films. We explore the growth of CrSb crystalline films by magnetron sputtering on a variety of crystalline seed layers and underlying single-crystalline substrates with hexagonal or cubic symmetry, which allows the stabilization of different crystallographic orientations of CrSb, while also tuning epitaxial strain. This work, while providing a testbed for the fundamental study of altermagnets and their structure-properties relationship, also opens avenues for the use of altermagnetic CrSb for antiferromagnetic devices with new functionalities relying on the manipulation of charge, orbital and spin degrees of freedom.

MA 33.6 Wed 16:15 HSZ/0002

Emergent d-Wave Order from Altermagnetic Symmetry in Cuprate and Nickelate Superconductors — •Tom G. Saunderson[1], James F. Annett[2], and Samir Lounis[1] — [1]Institute of Physics and Halle-Berlin-Regensburg Cluster of Excellence CCE, Martin-Luther-University Halle-Wittenberg, Halle(Saale) 06120, Germany — [2]H. H. Wills Physics Laboratory, University of Bristol, Tyndall Avenue, Bristol BS8-1TL, United Kingdom

Since the discovery of cuprate high-T_c superconductivity, numerous theoretical frameworks have been proposed to explain its mechanism. Anderson's RVB picture [1] and U(1) gauge theory [2], for example, motivate a minimal one-band description that largely integrates out the role of oxygen. By contrast, 'altermagnetism' [3] produces a d-

wave like k-space magnetic texture originating from alternatingly rotated *nonmagnetic* cages. In this talk, we take the central ideas of altermagnetism and apply them to both cuprate and nickelate families of superconductors. We show that the in-plane oxygen sublattice of CuO_2/NiO_2 layers, ubiquitous in these materials, intrinsically realizes the same symmetry. By imposing an *oxygen-centered*, staggered s-wave pairing, one obtains a d-wave gap with perfect C_4 symmetry, demonstrated self-consistently in $NdNiO_2$ from first principles. This description of superconductivity enables a direct mapping between a real-space order parameter and a lattice-based picture, opening the possibility of treating superconductivity and Hubbard-model physics on the same footing. [1] Science **235**, 1196 (1987); [2] Phys. Rev. Lett. **76**, 503 (1996); [3] Phys. Rev. X **12**, 031042 (2022).

15 min break

MA 33.7 Wed 16:45 HSZ/0002

Medium-Throughput Evaluation of Topological Transports for Altermagnets — •Fu Li[1], Bo Zhao[1], Shengqiao Wang[2], Chen Shen[1], Hao Wang[1], and Hongbin Zhang[1] — [1]Institute of Materials Science,Technical University of Darmstadt, 64287 Darmstadt, Germany — [2]School of Materials Science and Engineering, Jilin University, Changchun, 130012, China

The recent surge of interest in altermagnetism, distinct from both ferromagnetism and antiferromagnetism, highlights its potential for a wide range of technological applications. Quantifying their topological transport properties can provide essential guidance on the characterization of such materials while assessing their suitability for spintronic and optical applications. In this work, we collect around 200 known altermagnets (including also those with odd parity) based on symmetry arguments and perform medium-throughput density functional theory calculations to evaluate their topological transport properties such as anomalous Hall conductivity, magneto-optical Kerr effect, and shift current. Focusing on cases with broken inversion symmetry (i.e., polar altermagnets and odd-parity magnets), it is observed that the shift current can be large, making them promising for bulk photovoltaic applications. Furthermore, taking ferroelectric Fe2Mo3O8 as an example, it is demonstrated that its shift current can be controlled by external electric fields. Our results provide significant features characterizing altermagnets, and the obtained electronic structure can be starting point to investigate other intriguing physical properties.

MA 33.8 Wed 17:00 HSZ/0002

Electronic Raman spectroscopy in altermagnet MnTe — •Garima Garima[1,2,3], Thomas Böhm[1,3], Rudi Hackl[3], Bernd Büchner[1,3], and Jochen Geck[1,2] — [1]Institut für Festkörper- und Materialphysik, Technische Universität Dresden, 01062 Dresden, Germany — [2]Würzburg-Dresden Cluster of Excellence ct.qmat, Technische Universität Dresden, 01062 Dresden, Germany — [3]Leibniz Institute for Solid Sate and Materials Research Dresden, Helmholtzstrasse 20, D-01069 Dresden, Germany

Altermagnets, the new class of magnets, are promising candidates to realize spintronic and spin-information processing devices. The new magnetic state is characterized by broken time-reversal symmetry, resulting in spin-split bands in momentum space and hence provides a basis to foster chiral magnetic excitations. Here, we utilize electronic Raman scattering to investigate chirality in the hexagonal altermagnet MnTe. In consistency with RIXS experiments [1], our polarization-resolved results reveal optical signatures of 2-magnon excitations, appearing below the magnetic transition temperature of 310 K in the chiral A_{2g} channel. [1] Jost, D., et al. Chiral altermagnon in MnTe. arXiv preprint arXiv:2501.17380.

MA 33.9 Wed 17:15 HSZ/0002

Optically tunable spin transport in bilayer altermagnetic Mott insulators — Niklas Sicheler[1], Roberto Raimondi[2], Giorgio Sangiovanni[1], and •Lorenzo Del Re[1] — [1]Würzburg University — [2]Roma Tre

Altermagnets are a class of materials in which antiferromagnetic order coexists with non-relativistic spin splitting (NRSS), offering a promising route to spintronic functionalities without relying on strong spin*orbit coupling. In this work, we study a two-dimensional bilayer Mott insulator that realizes an altermagnetic phase shaped by the interplay between spin and layer degrees of freedom. This coupling produces a rich symmetry-breaking structure in which magnetic order is intertwined with inter-layer excitonic correlations. The layer polarization*tunable through an external gate voltage*acts as a key control parameter for this excitonic altermagnetic state. We demonstrate that an in-plane electric field applied with opposite signs across the layers generates a polarization current, which in turn drives a spin current within each layer. While the polarization current itself is isotropic, the induced spin current is highly anisotropic and can be reversed by tuning the photon energy. These results identify a mechanism for electrically and optically manipulating spin transport in correlated altermagnets, and highlight the central role of excitons in enabling controllable spin responses.

MA 33.10 Wed 17:30 HSZ/0002

Microscopic origin of the magnetic interactions and their experimental signatures in altermagnetic La2O3Mn2Se2 — •Laura Garcia-Gassull[1], Aleksandar Razpopov[1], Panagiotis P. Stavropoulos[1], Igor I. Mazin[2], and Roser Valentí[1] — [1]Goethe-Universität Frankfurt, Germany — [2]George Mason University, Fairfax, USA

Our analysis on the altermagnetic candidate La2O3Mn2Se2, realized on an inverse Lieb lattice, combines ab initio calculations, analytical modeling and spin-wave theory. We resolve a contradiction within the existing literature, where the GKA rules for half-filled orbitals have been applied, instead of the high-spin configuration ones. By studying the exchange pathways we show that the antiferromagnetic nearest-neighbor dominates over the next-nearest-neighbor coupling, since both direct exchange and superexchange cooperatively stabilize the magnetic ground state.

Going beyond static interactions, we compute the magnon spectrum within linear spin-wave theory and identify experimental signatures of the altermagnetic exchange, a characteristic chiral splitting of magnon bands driven the inequivalent second-neighbor exchanges.

Our work not only clarifies the microscopic origin of altermagnetism, but also offers concrete predictions for its experimental verification, reinforcing La2O3Mn2Se2 as a model system for studying altermagnetic physics. You can find more details at: https://arxiv.org/pdf/2506.21661.

We thank the (DFG) through the TRR 288 (project B05).

MA 33.11 Wed 17:45 HSZ/0002

Altermagnetic Magnons in MnTe Probed by CD-RIXS — Daniel Jost[1,2], Resham B. Regmi[3,4], Eder G. Lomeli[5,1], Samuel Sahel-Schackis[6,2,7], •Monika Scheufele[8,9], Marcel Neuhaus[2], Rachel Nickel[10], Flora Yakhou[10], Kurt Kummer[10], Nicholas B. Brookes[10], Lingjia Shen[2], Georgi L. Dakovski[2], Nirmal J. Ghimire[3,4], Stephan Geprägs[8], and Matthias F. Kling[6,2,11] — [1]Stanford Inst. for Material and Energy Science, SLAC, USA — [2]Linac Coherent Light Source, SLAC, USA — [3]Dept. of Physics and Astronomy, Univ. of Notre Dame, USA — [4]Stravropoulos Center for Complex Quantum Matter, Univ. of Notre Dame, USA — [5]Dept. of Materials Science and Engineering, Stanford Univ., USA — [6]Stanford PULSE Inst., SLAC, USA — [7]Dept. of Physics, Stanford Univ., USA — [8]Walther-Meißner-Inst., BAdW, Germany — [9]TUM School of Natural Sciences, Physics Dept., TUM, Germany — [10]ESRF, France — [11]Dept. of Applied Physics, Stanford Univ., USA

Altermagnetism has emerged as a novel magnetic order combining features of both ferro- and antiferromagnetism. Despite their compensated spin structure, altermagnets exhibit symmetry-induced momentum-dependent splitting of magnon bands with well-defined chirality. This splitting must reflect the material's point-group symmetry. Here, we demonstrate the chiral character of these magnons by circular-dichroism resonant inelastic X-ray scattering (CD-RIXS) on altermagnetic α-MnTe [1]. We reveal momentum-dependent dichroism, indicating the polarization-dependent magnon splitting consistent with a g-wave symmetry. [1] D. Jost *et al.*, arXiv:2501.17380v2 (2025).

MA 33.12 Wed 18:00 HSZ/0002

Robust spin splitting and optical control in a layered altermagnet — •Alessandro De Vita[1,2], Chiara Bigi[3], Davide Romanin[4], Ralph Ernstorfer[1,2], Ilija Zeljkovic[5], Younghun Hwang[6], Matteo Calandra[7], Jill A. Miwa[8], and Federico Mazzola[9] — [1]Institut für Physik und Astronomie, Technische Universität Berlin — [2]Fritz Haber Institut der Max Planck Gesellshaft — [3]Synchrotron SOLEIL — [4]Université Paris-Saclay, CNRS — [5]Department of Physics, Boston College — [6]Electricity and Electronics and Semiconductor Applications Ulsan College — [7]Department of Physics, University of Trento — [8]Department of Physics and Astronomy, Interdisciplinary Nanoscience Center, Aarhus University —

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Altermagnetism defies conventional classifications of collinear magnetic phases, with its unique combination of spin-dependent symmetries, net-zero magnetization, and anomalous Hall transport. Although altermagnetic states have been realized experimentally, their integration into functional devices has been hindered by the structural rigidity and poor tunability of existing materials. First, through cobalt intercalation of the superconducting 2H-NbSe2 polymorph, we induce and stabilize a robust altermagnetic phase and, via angle- and spin-resolved photoemission spectroscopy (spin-ARPES), we directly observe the lifting of Kramers degeneracy. Then, using ultrafast laser pulses, we demonstrate how a low-temperature phase can be quenched. Our findings open pathways to spin-based technologies and lay a foundation for advancing the emerging field of altertronics.

MA 33.13 Wed 18:15 HSZ/0002

Odd-parity-wave spin-polarized multiferroics — •Jan Priessnitz, Johannes Mitscherling, and Libor Šmejkal — Max Planck Institute for Physics of Complex Systems, Dresden, Germany

Combining ferroelectricity with spin polarization in ferromagnets is difficult due to the poor compatibility of insulating band structures and ferromagnetism. Recently, an alternative strategy based on combining time-reversal-broken spin polarization in altermagnetic insulators and ferroelectricity into type-I multiferroics was suggested [1]. Here we propose a different strategy based on time-reversal-symmetric odd-parity-wave spin polarization, which we demonstrate in type-II multiferroics induced by noncollinear magnetism [2,3]. Via state-of-the-art spin group theory and first-principle calculations, we demonstrate the spin polarization in $GdMn_2O_5$, a type-II multiferroic material combining coplanar p-wave magnetic order with ferroelectric order. Furthermore, we propose the antialtermagnetoelectric effect – cross-coupling between ferroelectric and odd-parity-wave time-reversal-symmetric spin polarization. The calculated switching path, influenced by exchange fields and spin-orbit coupling, and consistent with previous studies of ferroelectricity in this material, connects two distinct magnetic states with opposite signs of both electric and spin polarization.

[1] L. Šmejkal, arXiv:2411.19928.
[2] A. Birk Hellenes et al., arXiv:2309.01607v3.
[3] A. Chakraborty et al., Nat Commun 16, 7270 (2025).